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Prioritizing Islands for the Eradication of Invasive Vertebrates in the United Kingdom Overseas Territories

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Abstract: *Invasive alien species are one of the primary threats to native biodiversity on islands worldwide. Consequently, eradicating invasive species from islands has become a mainstream conservation practice. Deciding which islands have the highest priority for eradication is of strategic importance to allocate limited resources to achieve maximum conservation benefit. Previous island prioritizations focused either on a narrow set of native species or on a small geographic area. We devised a prioritization approach that incorporates all threatened native terrestrial vertebrates and all invasive terrestrial vertebrates occurring on 11 U.K. overseas territories, which comprise over 2000 islands ranging from the sub-Antarctic to the tropics. Our approach includes eradication feasibility and distinguishes between the potential and realistic conservation value of an eradication, which reflects the benefit that would accrue following eradication of either all invasive species or only those species for which eradication techniques currently exist. We identified the top 25 priority islands for invasive species eradication that together would benefit extant populations of 155 native species including 45 globally threatened species. The 5 most valuable islands included the 2 World Heritage islands Gough (South Atlantic) and Henderson (South Pacific) that feature unique seabird colonies, and Anegada, Little Cayman, and Guana Island in the Caribbean that feature a unique reptile fauna. This prioritization can be rapidly repeated if new information or techniques become available, and the approach could be replicated elsewhere in the world.*

Priorización de Islas para la Erradicación de Vertebrados Invasores en los Territorios Exteriores del Reino Unido

Keywords: alien invasive vertebrates, biodiversity conservation, eradication, invasive species, island restoration, non-native species, reptiles, rodents

Resumen: *Las especies invasoras son una de las principales amenazas para la biodiversidad nativa de las islas en todo el mundo. En consecuencia, erradicar a las especies invasoras de las islas se ha vuelto una práctica de conservación convencional. Decidir si las islas tienen la prioridad más alta para la erradicación es de importancia estratégica para asignar recursos limitados a obtener un beneficio máximo de conservación. La priorización previa de islas se ha enfocado en un conjunto limitado de especies nativas o en un área geográfica pequeña. Concebimos una estrategia de priorización que incorpora a todos los vertebrados terrestres nativos amenazados y a todos los vertebrados terrestres invasores que existen en once territorios externos del Reino Unido, que comprende más de 2000 islas que van desde la región sub-antártica hasta los trópicos. Nuestra estrategia incluye la viabilidad de la erradicación y distingue entre el valor de conservación potencial y el valor realista de de una erradicación, lo que refleja el beneficio que se acumularía después de la erradicación de todas las especies invasoras o sólo de aquellas especies para las cuales existen actualmente técnicas de*

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erradicación. Identificamos a las 25 islas más importantes para la priorización de erradicación de especies invasoras, que en conjunto beneficiarían a las poblaciones existentes de 155 especies nativas, incluidas 45 especies amenazadas a nivel global. Las cinco islas más valiosas incluyen dos islas de patrimonio mundial: Gough (Atlántico sur) y Henderson (Pacífico sur), que poseen colonias únicas de aves marinas; además de las islas Anegada, Little Cayman y Guana en el Caribe, que presentan una fauna única de reptiles. Esta priorización puede repetirse rápidamente si nueva información o nuevas técnicas se vuelven disponibles, y la estrategia podría replicarse en otros lugares del mundo.

Palabras Clave: conservación de la biodiversidad, erradicación, especies invasoras, especies no-nativas, reptiles, restauración de islas, roedores, vertebrados invasores

Introduction

Invasive alien species are recognized as one of the principle threats to native biodiversity globally. Particularly on islands, invasive alien species threaten native species through competition and predation, habitat modification, transmission of disease, disruption of ecosystem functions, and changing trophic dynamics (Simberloff 2009; Simberloff et al. 2013). Globally, some of the most damaging and widespread invasive alien species on islands are vertebrates, in particular mammals. Invasive rodents (rats [*Rattus* sp.] and house mouse [*Mus musculus*]) occur on over 80% of oceanic islands (Russell et al. 2008*b*) and pose a significant threat to island biodiversity (Courchamp et al. 2003; Towns et al. 2006; Jones et al. 2008). Feral cats (*Felis catus)* have contributed to at least 14% of all bird, mammal, and reptile extinctions and the decline of at least 8% of critically endangered birds, mammals, and reptiles (Medina et al. 2011). Other mammalian predators such as the small Asian mongoose (*Herpestes javanicus*) are responsible for the extinction and decline of many reptile species (Hays & Conant 2007; Hedges & Conn 2012). Feral herbivores, in particular goats (*Capra hircus*) and rabbits (*Oryctolagus cuniculus*), can also fundamentally change island ecosystems by altering native vegetation through herbivory, dispersal of non-native plant seeds, and exacerbating soil erosion (Coblentz 1978; Courchamp et al. 2003).

The eradication of invasive alien species from islands has become a mainstream conservation practice; there have been over 1000 successful vertebrate eradications up to 2013 (Keitt et al. 2011; Island Conservation 2012). The ability to effectively remove invasive alien vertebrates from islands is improving as techniques continue to be refined (Veitch et al. 2011). As a result, the number of islands on which eradication of invasive alien vertebrates is technically feasible and could provide a conservation benefit is increasing.

Eradications can be complex to implement and require substantial amounts of planning time. To make the best use of limited conservation resources, it is vital to assess the biological need for eradication against the feasibility and sustainability of operations (Saunders et al. 2011; Martínez-Abraín & Oro 2013). Similar to systematic conservation planning for the location of reserves (Sarkar et al. 2006), an established approach to prioritize islands where an eradication would achieve the greatest net benefit for extant biodiversity is an analytical comparison of the costs and benefits of eradicating invasive alien vertebrates. So far, however, these eradication prioritizations have either focused on a small set of native taxa such as birds (Brooke et al. 2007*b*; Ratcliffe et al. 2009; Capizzi et al. 2010) or on small spatial scales (Harris et al. 2012).

We expanded previous approaches to assess the benefit to all species of native vertebrates resulting from the eradication of invasive vertebrates on more than 2000 islands ranging from sub-Antarctic to tropical latitudes. We performed this prioritization for islands belonging to overseas territories of the United Kingdom, which are home to more than 300 globally threatened species (Hilton & Cuthbert 2010; IUCN 2012) and harbor over 2000 invasive alien plant and animal species (Defra 2012) known to cause a range of negative impacts (Butchart et al. 2006; Szabo et al. 2012). Although these islands span a wide range of latitudes and ecosystems, they are politically all subordinated to the U.K. government and therefore present an administratively cohesive group of geographically and biologically diverse islands. The control and eradication of invasive alien species is a key priority for the U.K. government (Defra 2009), and our prioritization therefore provides strategic guidance for governments and conservation organizations in allocating resources to the conservation of a large number of species that are globally threatened with extinction. The approach we applied expands previous prioritizations geographically, taxonomically, and methodologically and can be replicated elsewhere and for other taxa.

Methods

Data Collection

Eleven U.K. overseas territories (Fig. 1) were included in the study: Anguilla; Bermuda; British Indian Ocean Territory; British Virgin Islands; Cayman Islands; Falkland Islands; Montserrat; Pitcairn Islands; Saint Helena, Ascension and Tristan da Cunha; South Georgia and the South Sandwich Islands; and Turks and Caicos Islands.

For all islands within these territories, we compiled data in 3 main categories: physical and social

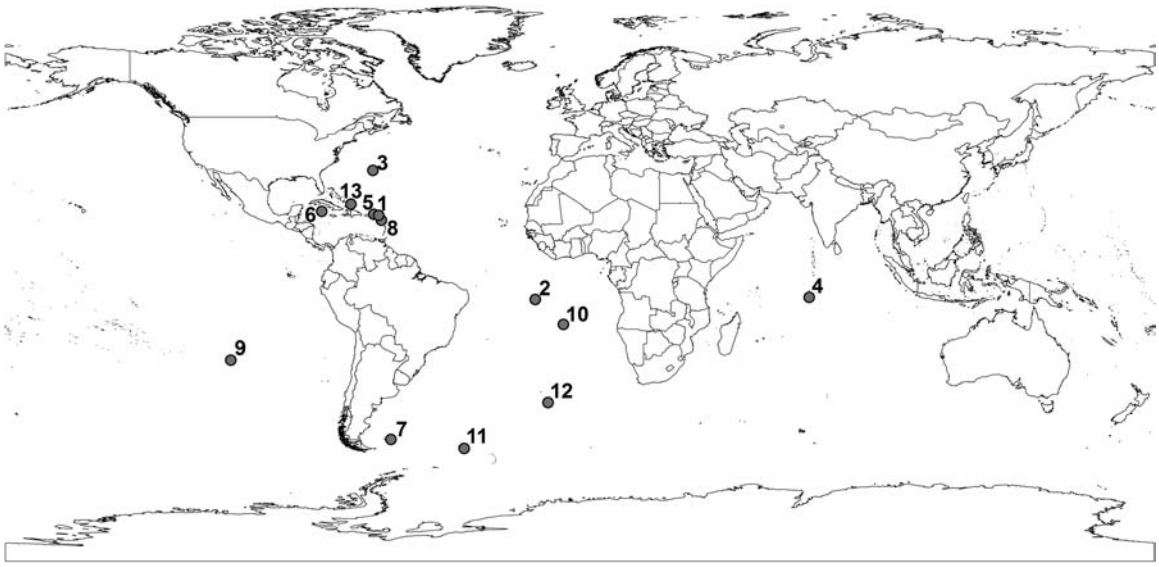

Figure 1. Location of the U.K. overseas territories where the biodiversity benefit of eradicating invasive alien vertebrates was assessed: 1, Anguilla; 2, Ascension; 3, Bermuda; 4, British Indian Ocean Territory; 5, British Virgin Islands; 6, Cayman Islands; 7, Falkland Islands; 8, Montserrat; 9, Pitcairn Islands; 10, Saint Helena; 11, South Georgia and South Sandwich Islands; 12, Tristan da Cunha; 13, Turks and Caicos Islands.

information for each island; data on a subset of native terrestrial vertebrate species (hereafter native species), and data on all terrestrial alien vertebrates that have established wild self-sustaining populations (hereafter invasive species). Data were compiled from gray and published literature, reports, and government departments between September 2012 and January 2013 (see Supporting Information).

Island Information

We used the Global Island Database (UNEP-WCMC 2013) to compile a list of all islands, island area, and human population; new islands were added where higher resolution data were available from databases at government departments or conservation and research institutions. Where no information on human population was available, population was estimated from satellite imagery in Google Earth based on the number of buildings on the island and assuming that each building was inhabited by 4 people. Human population was categorized into the categories of unknown, 0, 1–10, 11–100, 101–1000, 1001–10,000, and >10,000.

Native Species Information

For all islands in the 11 territories, we collected information on all globally threatened terrestrial vertebrate species (including marine turtles) as listed on the International Union for Conservation of Nature Red List (IUCN 2012) and on all colonial seabird species and restricted-range bird species (as defined by Stattersfield et al. 2005). We also included a number of Caribbean reptiles judged to be of conservation concern because they are endemic to a single country, or inhabit fewer than 15 islands, although their global threat status had not yet been assessed (following Powell & Henderson 2012). Nomenclature for all native species followed IUCN (2012). For each island, we recorded all native species and their present breeding status (within the last 20 years) as confirmed, probable, potential, data deficient, extirpated, or nonbreeding based on definitions in the Threatened Island Biodiversity database (Threatened Island Biodiversity Database Partners 2012). Historical breeding status (between 21 and 200 years ago) was also recorded as either confirmed, probable, potential, or data deficient (see Supporting Information for full definitions) and was used to assess which species may either naturally recolonize or be reintroduced to islands after eradication.

Invasive Species Information

For every island, we collected information on the presence of invasive alien vertebrates in one of the following categories: confirmed, suspected, on-going eradication, extirpated, and unknown (Supporting Information). All invasive and native species information is available in a database in the Supporting Information.

Prioritizing Islands for the Eradication of Invasive Alien Vertebrates

The priority of an island for invasive species eradication took into account conservation value, feasibility of

eradicating invasive species based on the island's area and human population size, and natural reinvasion risk. Due to the lack of consistent data, social feasibility, anthropogenic reinvasion risk, and terrain complexity were not incorporated into the prioritization. The overall conservation value (hereafter eradication benefit [EB]) was calculated as the difference between the maximally possible conservation value for all extant native species on an island (hereafter potential conservation value [PCV]) and a more realistic conservation value (RCV) based on current practicalities and limitations to eradication operations (hereafter RCV); thus, EB took into account that on many islands, it may not be feasible to eradicate all harmful invasive species ($EB_i = PCV_i - RCV_i$). The islands with the largest EB were considered top priorities for eradication. We performed all calculations in R 2.15.3 (R Development Core Team 2010). Code and detailed information is in Supporting Information.

Potential Conservation Value

The PCV of an island eradication was adapted from Brooke et al. (2007*b*) and represented the biodiversity benefit of eradicating all invasive alien vertebrates from an island in order to avoid unforeseen secondary effects. The PCV was calculated as the sum of all conservation values for each native species breeding on an island that would benefit from an eradication of invasive vertebrates, where conservation value was the product of threat status, irreplaceability, and vulnerability to invasive species (Supporting Information).

Threat status (*T*) was scored using both a logarithmic and linear scale with the IUCN categories of critically endangered, endangered, vulnerable, near threatened, and least concern being scored as 100, 10, 1, 0.1, and 0.01 (logarithmic scale) or 5, 4, 3, 2, and 1 (linear scale), respectively. Unassessed reptile species were given a score equivalent to vulnerable. This classification may be an under- or overrepresentation of extinction risk and will need to be adjusted when the species are formally assessed by the IUCN. Caribbean skinks (Scincidae), although not yet listed by the IUCN, were assigned the categories recommended by Hedges & Conn (2012).

Irreplaceability (*I*) for each island was based on the total number of islands supporting the native species or the percentage of the species' global or regional breeding population on the island (Table 1). We acknowledge that in some cases, a small range may lead to both a high threat category and a high irreplaceability score. However, in the vast majority of cases, the 2 values represent fundamentally different properties and even critically endangered species may occur on several islands, so the irreplaceability score highlights the unique value of an island if it is of global importance for a particular species.

The severity of impact (*Z*) was the maximum impact of any invasive alien vertebrate species affecting a native species on a given island. We assessed the impact of each invasive alien vertebrate species confirmed or suspected to occur on an island on each native species on that island. These interactions were assessed using evidence of impacts on the native species or on a related or similar native species or of impacts of a morphologically similar invasive species from the literature. Brooke et al. (2007*b*) used impact scores of 1–5, but for the broader range of taxa we considered, the severity of impacts is considerably less well understood, so we chose an impact scale of 0–2. The severity of impact was scored as 2 if the invasive species was known, suspected, or had the potential to have a detrimental effect on the native species by causing population declines through predation, habitat modification, competition, or the spread of disease. Severity of impact was scored as 1 if the invasive species co-existed with the native species but was likely to prevent it from reaching its maximum potential population (e.g., by suppressing breeding success or reducing habitat suitability). Severity of impact was scored as 0 if no apparent negative effects upon the native species were known. If there was uncertainty of the level of impact and no information was available from similar species, a score of 2 was assigned, thus assuming a worst case scenario.

The PCV of an island also included extirpated species that could recolonize or be reintroduced following invasive species eradication. Because natural recolonization or reintroduction is not guaranteed following the removal of invasive species from an island, the conservation value of extirpated species was given only half the weight of extant species (Eq. 1). Overall, the PCV was calculated for each island as

$$PCV_i = \left(\sum_{1}^{s} T_{s,i} \times I_{s,i} \times Z_{s,i}\right) + 0.5 \times \left(\sum_{1}^{p} T_{p,i} \times I_{p,i} \times Z_{p,i}\right) \quad (1)$$

where *T* is the threat status of each native species *s* occurring on island *i* or native species *p* that may potentially recolonize or be reintroduced to the island following eradication; *I* is the irreplaceability of each native species' global importance on a particular island; and *Z* is the severity of impact of all alien species on island *i* on the native species *s* or *p*.

For each island, 4 different PCV scores were calculated using the 4 possible combinations of threat status and irreplaceability scores. Because these different scoring approaches resulted in noncomparable values and there is currently no guidance on which approach performs best, we ranked islands according to all 4 approaches and used the median rank for prioritization (Supporting Information).

Table 1. Irreplaceability criteria for each native species on a given island and the corresponding scores used to assess the conservation value of alien vertebrate eradication.*

	Score	
Criterion	*Log scale*	*Linear scale*
Single island endemic or island supports >90% of GBP	100	5
Occurs on 2–5 islands or island supports 50–90% of GBP	10	4
Occurs on 6–10 islands or island supports 1–50% of GBP or 50–100% of RBP	1	3
Does not qualify for the above but is a restricted-range species or island supports 1–50% of RBP; or is a seabird and island listed as an IBA under criterion A4iii because it is known or thought to hold on a regular basis >10,000 pairs of seabirds of one or more species; or is globally or regionally important for wintering or supports nonbreeding congregations of an IBA trigger species	0.1	2
Not any of the above	0.01	1

Abbreviations: GBP, global breeding population; RBP, regional breeding population; IBA, important bird area.

Realistic Conservation Value

To assess a more realistic conservation value of islands, we calculated realistic conservation value for each island using the same formula as for PCV but included only invasive species that could be considered feasible to eradicate. When calculating RCV, the Z score used for each native species was the highest of those invasive species remaining after eradicating all invasive species for which an eradication was logistically feasible with existing techniques and sensible given the natural reinvasion risk. We classified invasive species into 3 categories based on commonly used eradication techniques to determine which invasive species were feasible to remove from islands. We used global data analyses of completed and planned eradications (Island Conservation 2012) and consulted eradication experts to determine whether an eradication could be considered feasible or not. Feasibility for eradication programs is ideally determined by a wide range of site-specific social, technical, and ecological factors (Morrison et al. 2011), but human population size is a key limiting factor for eradication feasibility. We considered eradication of rodents, rabbits, cats, dogs, mongooses, green iguanas, monitor lizards, and hares feasible if <1000 humans inhabited an island and eradication of goats, sheep, pigs, cows, and reindeer feasible if <10,000 humans inhabited an island and island size was equal to or smaller than the largest island where eradication of the species had been accomplished to date (Island Conservation 2012). All other species were considered not feasible to eradicate on any island, except chickens on islands <5 km^2, cane toads (*Rhinella marina*) on islands <10 ha, and red-eared slider freshwater turtle (*Trachemys scripta elegans*) on islands with <1000 human inhabitants. Although we acknowledge that invasive birds have been successfully eradicated from small, isolated islands (e.g., Common Mynas [*Acridotheres tristis*] in the Seychelles), similar situations do not occur in the U.K. overseas territories. Eradication of all other amphibian and reptile species was not considered feasible due to a current lack of effective eradication methods for these species (Pitt et al. 2005; Kraus 2009).

The long-term success of an eradication project can be jeopardized by either natural or human-assisted reinvasion of the eradicated species (Clout & Russell 2008; Russell et al. 2008*b*; Harris et al. 2012). We considered the reinvasion risk in our prioritization by excluding an eradication as unlikely to yield lasting benefits if unassisted reinvasion via swimming was likely during or soon after an attempted eradication. Several mammals (e.g., rodents, mustelids, deer, and foxes) can swim between islands and may reinvade islands after eradication. However, besides rodents, the remaining swimming species inhabited very few islands in our study area, and their reinvasion risk after eradication was negligible for our overall assessment. Rodent eradication on islands within 2 km of an island assessed as being unfeasible for rodent eradication was excluded based on the maximum swimming distance recorded for rodents (Russell et al. 2008*a*,2008*b*). Eradication on these islands may be technically feasible; however, due to the high reinvasion risk, they are less likely to maintain the benefit of eradication. Therefore, we excluded them from our prioritization.

Results

We evaluated 2499 islands that supported 216 native vertebrate species, of which 67 were globally threatened (Table 2) and 4 have been extirpated from the focal countries (Roosevelt's giant anole [*Anolis roosevelti]*, Puerto Rican crested toad [*Peltophryne lemur*], Giant Kingbird [*Tyrannus cubensis*], and Cuban crocodile [*Crocodylus cubensis*]).

Only the 191 islands with at least 1 native species present or historically present and at least 1 invasive species that had a negative effect were included in the prioritization. Of the 25 islands with the highest PCV (Table 3), 3 were considered unfeasible for any

Table 2. Number of native terrestrial vertebrate species present on islands within the 11 U.K. overseas territories assessed in this study listed by their extinction risk and taxonomic order.*

	Status					
Taxonomic order	*CR*	*EN*	*VU*	*NT*	*LC*	*UR*
Seabirds	1	8	7	7	68	0
Landbirds	3	3	12	11	31	0
Reptiles	12	9	6	1	0	31
Amphibians	2	2	0	0	0	0
Mammals	0	0	2	0	0	0
Total	**18**	**22**	**27**	**19**	**99**	**31**

**Abbreviations: CR, critically endangered; EN, endangered; VU, vulnerable; NT, near threatened; LC, least concern; UR, unassessed reptiles of conservation concern.*

eradication due to either human population size or invasive species groups present. Grand Cayman, Tortola, and Anguilla all have human populations of >10,000, and invasive vertebrate eradication was considered infeasible. Other islands with human populations over 1000 from which many species were unfeasible to eradicate included Montserrat, Cayman Brac, Saint Helena, Virgin Gorda, and Grand Turk. Due to logistical limitations to eradication, these islands could not achieve the maximal conservation benefit and therefore scored substantially lower when ranked by eradication benefit (Table 4).

Ten of the 11 focal territories were represented in the top 25 islands ranked by eradication benefit; the list was dominated by islands from the Turks and Caicos Islands (5 islands) and British Virgin Islands (9 islands; Table 4). Of the 25 top priority islands, 11 have permanent human habitation (excluding research bases). The largest population was on Montserrat (4922), which made it the only island in the top 25 on which eradication of a harmful invasive species (rodents) was not feasible. Eradicating invasive species from these 25 islands would provide a conservation benefit to 155 native species of which 45 are globally threatened (16 reptiles, 14 seabirds, 10 land birds, 3 amphibians, and 2 mammals).

The top 5 priority islands would benefit from invasive alien vertebrate eradication because at the time invasive rodents were affecting native populations of seabirds and endemic land birds (Gough and Henderson Islands) or invasive mammals were affecting endemic reptiles (Anegada, Little Cayman, and Guana Island; Table 4).

Discussion

Our assessment is one of the most wide-ranging geographic and taxonomic prioritizations of invasive alien vertebrate eradications undertaken to date and substantially expands the scope of previous work (Brooke et al. 2007*b*; Capizzi et al. 2010; Harris et al. 2012). As a consequence of the broad taxonomic and geographic scope, methods to quantify biodiversity benefits had to be standardized for a wide range of species and countries where the quality and quantity of available data varied considerably. The arbitrary nature of different scales in conservation prioritizations has been criticized (Game et al. 2013), and a different scoring system of threats or impacts may lead to a slightly different set of priority islands. However, we applied a variety of scoring scales, and our results present the consensus among these approaches and are therefore robust to moderate changes in the scoring choices.

We produced 2 robust lists of islands that would benefit the most from invasive vertebrate eradications. The first list (Table 3) is based on the potential conservation value that would accrue if all invasive species could be eradicated and includes tropical islands such as Montserrat, Grand Cayman, and Tortola that harbor a rich native biodiversity but also many invasive species and large human populations. Eradicating invasive species from human-inhabited islands is currently more difficult and prone to failure than eradicating these species from uninhabited islands (Ogden & Gilbert 2009; Oppel et al. 2011; Glen et al. 2013). Table 3 therefore represents a list that is currently unrealistic. We included this priority list to emphasize which island faunas would benefit the most from the removal of all invasive vertebrate species regardless of practical limitations.

Our second priority list (Table 4) resulted from explicitly considering the current practical limitations, and we used thresholds of island and human population size based on completed and planned eradications (Island Conservation 2012) plus expert opinion to guide feasibility of invasive species eradication on islands. However, feasibility for invasive species eradications will be best determined by experts reviewing the social, technical, and ecological circumstances of individual islands. The suite of high priority islands we identified as feasible for eradication can now be examined in greater detail. We recommend repeating our prioritization at regular intervals when new information or new techniques become available.

Eradication Priorities in the U.K. Overseas Territories

The top 25 priority islands where invasive vertebrate eradication was identified as feasible cover a broad geographic range from the sub-Antarctic to the tropics. Successful eradication of invasive vertebrates on these islands would benefit 155 native vertebrate species, including 45 globally threatened species. This set of islands included 2 World Heritage sites (Gough and Henderson Islands) and provides strategic guidance for the U.K. and overseas territory policy makers as to where investment in biodiversity protection and restoration would yield the greatest benefits.

Table 3. Top 25 islands for invasive alien vertebrate eradication within U.K. overseas territories ranked by potential conservation value, which assumes that all invasive alien vertebrate (IAV) species are eradicated from the target island.[a]

Rank	*Island*	*Territory*	*Number of globally threatened species[b]*	*Number of IAV species*	*Invasive alien vertebrate (IAV) species*
1	Montserrat	Montserrat	11 (4)	16	Feral cattle,[c] goat,[c] Rock Dove, Saint Lucia agouti,[c] common opossum,[c] donkey,[c] feral cat, Chicken, red-footed tortoise, Afro-American house gecko, sheep, brown rat, black rat, cane toad, Eurasian Collared-Dove, feral pig[c]
2	Gough	Saint Helena, Ascension and Tristan da Cunha	7 (0)	1	House mouse[c]
3	Cayman Brac	Cayman Islands	3 (7)	9	Feral cat, feral dog, Chicken, house mouse, brown rat, black rat, rock dove, Eurasian Collared-Dove, green iguana
4	Anegada	British Virgin Islands	5 (1)	15	Afro-American house gecko, feral cat,[c] feral dog,[c] goat,[c] feral cattle,[c] donkey,[c] house mouse,[c] Rock Dove, Cuban treefrog, sheep,[c] House Sparrow, feral pig,[c] green iguana,[c] brown rat,[c] Chicken
5	Grand Cayman	Cayman Islands	7 (5)	28	Wood Duck, Yellow-crowned Parrot, Mallard, green anole, Jamaican giant anole, brown anole, Red-masked Parakeet, eastern narrowmouth toad, cane toad, red-eared slider, North Antillean slider, yellow-headed gecko, Afro-American house gecko, green iguana, eastern glass lizard, southern ringneck snake, red cornsnake, brahminy blindsnake, feral cat, feral dog, Chicken, house mouse, brown rat, black rat, Rock Dove, Rose-ringed Parakeet, Eurasian Collared-Dove, Central American agouti
6	Little Cayman	Cayman Islands	6 (5)	7	Feral cat,[c] feral dog,[c] House mouse,[c] brown rat,[c] black rat,[c] green iguana,[c] brown anole
7	Saint Helena	Saint Helena, Ascension, and Tristan da Cunha	1 (0)	17	Common Myna, Chukar Partridge, Rock Dove, donkey,[c] Common Waxbill, feral cat, Madagascar Fody, Zebra Dove, Asian house gecko, house mouse, rabbit, Java Sparrow, Ring-necked Pheasant, brown rat, black rat, Yellow Canary, Gray's stream frog
8	Henderson	Pitcairn Islands	7 (0)	5	mottled snake-eyed skink, copper-tailed skink, mourning gecko, moth skink, Polynesian rat[c]
9	Tortola	British Virgin Islands	8 (1)	23	Lesser Antillean tree frog, Afro-American house gecko, Cuban treefrog, Florida red-bellied turtle, red-eared slider, green iguana, red cornsnake, small Indian mongoose, black rat, House Sparrow, feral cattle, Muschovy Duck, feral dog, goat, Rock Dove, donkey, feral cat, house mouse, sheep, brown rat, Eurasian Collared-Dove, feral pig, Chicken
10	Guana Island	British Virgin Islands	4 (0)	6	Afro-American house gecko, Cuban treefrog, African spurred tortoise, feral dog,[c] feral cat,[c] sheep[c]
11	Little Thatch Island	British Virgin Islands	4 (0)	4	Cuban treefrog, black rat,[c] House Sparrow, Rock Dove
12	Tristan da Cunha	Saint Helena, Ascension and Tristan da Cunha	6 (0)	5	Feral cattle,[c] donkey,[c] house mouse,[c] sheep,[c] black rat[c]
13	Norman Island	British Virgin Islands	2 (0)	3	Feral dog,[c] goat,[c] black rat[c]
14	Virgin Gorda	British Virgin Islands	6 (2)	18	Cuban treefrog, green iguana, Afro-American house gecko, black rat, feral cattle,[c] feral dog,[c] gGoat,[c] Rock Dove, donkey,[c] feral cat,[c] small ndian mongoose,[c] house mouse, sheep,[c] House Sparrow, brown rat, Eurasian Collared-Dove, feral pig,[c] Chicken
15	Cotton Cay	Turks and Caicos	3 (1)	2	Goat,[c] black rat[c]
15	Gibb's Cay	Turks and Caicos	2 (3)	1	Black rat[c]

Continued

Table 3. Continued

Rank	Island	Territory	Number of globally threatened species[b]	Number of IAV species	Invasive alien vertebrate (IAV) species
17	Necker Island	British Virgin Islands	2 (1)	5	Cuban treefrog, African spurred tortoise,[c] black rat,[c] House Sparrow, Rock Dove
17	Anguilla	Anguilla	7 (1)	18	green monkey,[c] rabbit, green anole, feral dog, goat, Rock Dove, Lesser Antillean tree frog, feral cat, Chicken, Afro-American house gecko, green iguana, house mouse, Cuban treefrog, red cornsnake, brahminy blindsnake, brown rat, black rat, cane toad
19	Jost Van Dyke	British Virgin Islands	4 (0)	17	Afro-American house gecko, green iguana,[c] small indian mongoose,[c] feral cattle,[c] Muschovy Duck, feral dog, goat,[c] Rock Dove, donkey,[c] feral cat,[c] house mouse,[c] Cuban treefrog, Sheep,[c] House Sparrow, black rat,[c] feral pig,[c] Chicken
19	Grand Turk	Turks and Caicos	2 (3)	12	Afro-American house gecko, green iguana, brahminy blindsnake, red cornsnake, *Sphaerodactylus mariguanae*, feral cattle,[c] feral dog, donkey,[c] feral horse,[c] feral cat, black rat, house mouse
21	East Caicos	Turks and Caicos	6 (5)	5	Feral cattle,[c] donkey,[c] feral cat,[c] black rat, house mouse[c]
22	Big Ambergris Cay	Turks and Caicos	3 (5)	6	Cuban treefrog, greenhouse frog, Afro-American house gecko, Chicken,[c] feral cat,[c] black rat[c]
22	Pitcairn	Pitcairn Islands	2 (0)	8	Goat,[c] copper-tailed skink, feral cat,[c] four-clawed gecko, Indopacific tree gecko, mourning gecko, moth skink, polynesian rat[c]
24	Scrub Island	Anguilla	1 (1)	2	Black rat,[c] goat[c]
25	South Georgia	South Georgia and South Sandwich Islands	5 (0)	2	Brown rat,[c] house mouse[c]

[a] *Because this assumption is currently unrealistic for several islands, a more realistic ranking is provided in Table 4.*
[b] *Number in parentheses is the number of unassessed reptile species.*
[c] *Species for which an eradication is currently considered feasible.*

Gough Island in the South Atlantic was identified as the highest priority island for invasive alien vertebrate eradication because mice severely impact the islands' globally important bird communities (Cuthbert & Hilton 2004; Wanless et al. 2007; Cuthbert et al. 2013). These include the critically endangered endemics Gough Bunting (*Rowetti goughensis*) and Tristan Albatross (*Diomedea dabbenena*), and 16 other globally important seabird populations. Similarly, on Henderson Island in the Pacific, invasive Polynesian rats (*Rattus exulans*) threaten 4 vulnerable endemic landbird species, the endangered endemic Henderson Petrel (*Pterodroma atrata*), and other important seabird populations. Both those islands were identified previously as high-priority eradication targets (Brooke et al. 2010; Hilton & Cuthbert 2010), and substantial ressources have been invested in a rodent eradication on Henderson Island (2011, unsuccessful) and planning of a mouse eradication on Gough. Our prioritization confirmed that these large eradication operations had been well justified and did not misdirect sparse conservation resources.

Anegada, Little Cayman, and Guana Islands in the Caribbean are high priorities primarily due to their threatened and endemic reptile fauna, and our prioritization is the first to highlight these islands. Anegada in the British Virgin Islands has 15 invasive species, 9 of which threaten the island's critically endangered endemic Anegada ground iguana (*Cyclura pinguis*), Anegada skink (*Spondylurus anegadae*), and 3 sea turtle species. Guana Island also has a population of Anegada ground iguana and the endangered Virgin Islands boa (*Epicrates monensis granti*) and Lesser Virgin Islands skink (*Spondylurus semitaeniatus*). These populations are threatened by predation from feral cats and dogs and habitat modification by feral sheep. Little Cayman harbors populations of 5 single island endemic reptiles (all currently unassessed by the IUCN) and of the critically endangered Sister Islands rock iguana (*Cyclura nubia caymanensis*). These and other species are threatened by the presence of feral cats, dogs, and rats. Our prioritization, which is the first to include reptiles in the assessment of eradication benefits, highlights that focussing on a single group of taxa (e.g., seabirds) may overlook many islands where the eradication of invasive vertebrates is critical to prevent the extinction of other taxa.

Table 4. Top 25 islands for invasive alien vertebrate eradication within U.K. overseas territories ranked by eradication benefit, which assumes that only those invasive alien vertebrate (IAV) species are eradicated for which technically and logistically feasible eradication techniques currently exist (as of January 2013).

Rank	*Island*	*Territory*	*Number of globally threatened species*[a]	*Number of IAV species present*
1	Gough	Saint Helena, Ascension and Tristan da Cunha	7 (0)	1
2	Anegada	British Virgin Islands	5 (1)	15
3	Little Cayman	Cayman Islands	6 (5)	7
4	Henderson	Pitcairn Islands	7 (0)	5
5	Guana Island	British Virgin Islands	4 (0)	6
6	Tristan da Cunha	Saint Helena, Ascension and Tristan da Cunha	6 (0)	5
6	Norman Island	British Virgin Islands	2 (0)	3
8	Cotton Cay	Turks and Caicos	3 (1)	2
8	Necker Island	British Virgin Islands	2 (1)	5
10	Big Ambergris Cay	Turks and Caicos	3 (5)	6
11	South Georgia	South Georgia and South Sandwich Islands	5 (0)	2
12	Pitcairn	Pitcairn Islands	2 (0)	8
12	Jost Van Dyke	British Virgin Islands	4 (0)	17
12	Little Ambergris Cay	Turks and Caicos	2 (4)	2
15	Salt Cay	Turks and Caicos	1 (2)	7
16	New Island	Falkland Islands	3 (0)	4
17	French Cay	Turks and Caicos	1 (1)	2
18	Little Tobago	British Virgin Islands	1 (0)	2
19	Peter Island	British Virgin Islands	2 (0)	8
20	Ascension	Saint Helena, Ascension and Tristan da Cunha	2 (0)	13
21	Dog Island	Anguilla	1 (1)	1
22	Salt Island	British Virgin Islands	3 (0)	3
23	Montserrat	Montserrat	11 (4)	16
24	Great Dog	British Virgin Islands	1 (0)	2
25	Ile de la Passe	British Indian Ocean Territory	2 (0)	1

[a]*Number in parentheses is the number of unassessed reptile species.*

Eradicating rodents and other invasive vertebrates would likely yield additional benefits to native biodiversity that we could not formally quantify in our prioritization. Many native plants and invertebrates are adversely affected by mammals and would likely benefit from the eradication of invasive species (St Clair et al. 2011). Secondary effects resulting from the recovery of seabird populations and associated nutrient inputs may benefit native biodiversity on many islands (Mulder et al. 2009; Towns et al. 2009; Jones 2010). While the lack of consistent data prevented a thorough evaluation of additional benefits, the native biodiversity on the islands we prioritized would likely benefit from invasive vertebrate eradication to an even greater extent than we could demonstrate here.

A further benefit that our prioritization may have underestimated is the restoration potential of islands. Studies to date have largely ignored restoration potential in analyzing priorities for eradication. We considered the potential benefit of eradications to those native species for which there was evidence that they had previously been extirpated. However, there is a need for a comprehensive analysis that takes into account islands that may hold potential for assisted or natural recolonization, even if historical records are lacking, and that considers all islands regardless of the present existence of native and alien species. Such an approach would need to take an island's origin into account. Oceanic islands, such as Henderson Island, naturally have a more depauperate but endemic fauna than those connected historically by land bridges to continents and are therefore less likely to be naturally recolonized by extirpated species.

Our prioritization focused on conservation benefit and technical feasibility, but several other factors will further shape priorities for eradication. The importance of identifying the financial cost of eradication has been highlighted in previous studies (Martins et al. 2006; Brooke et al. 2007*a*; Capizzi et al. 2010). Estimating costs of an eradication is a complex process, especially when comparing islands across a wide geographic range and for a wide range of taxa. Although we have not incorporated costs in our prioritization, we emphasize the importance of conducting a detailed cost analysis prior to undertaking any eradication. Costs will also be influenced by local community support on inhabited islands and the social and cultural feasibility of an eradication is equally important and complex to estimate (Oppel et al. 2011; Glen et al. 2013). Although the costs for individual eradication efforts may be substantial (e.g., US$3.3 million for Tristan da Cunha, US$2.5 million for Gough, US$12.7 million for South Georgia), these amounts are tiny in the context of government budgets (McCarthy et al. 2012) and may be among the most effective conservation interventions (Hoffmann et al. 2010).

Our results will assist the governments of U.K. overseas territories in planning their biodiversity conservation action. Supporting and facilitating invasive vertebrate eradications will also allow the U.K. government and those territories that are signatories to the Convention on Biological Diversity to help fulfil their commitment to achieving Aichi Target 9, namely, that "invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated," and Aichi Target 12, under which "the extinction of known threatened species has been prevented and their conservation status . . . has been improved and sustained" (CBD 2010). Our approach could be updated once new information becomes available, but we urge decision makers to act now and make funding available to eradicate invasive alien vertebrates from some of the most important islands identified here to prevent further loss and degeneration of the unique native biodiversity on islands within the U.K. overseas territories.

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Supporting Information

References for data sources (Appendix S1), breeding status definitions for native and invasive species (Appendix S2), details of the island prioritization approach (Appendix S3), R code for the prioritization (Appendix S4), and raw data on islands, native, and invasive species on the UK overseas territories (Appendix S5) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

Table S1. Example of threat, irreplaceability and severity of impact scores for a fictitious island inhabited by 4 native species.

Table S2. Example of prioritizing 6 fictitious islands for vertebrate eradication by aggregating island ranks derived from 4 different scoring scales. The island with the highest eradication priority is highlighted in Red.

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